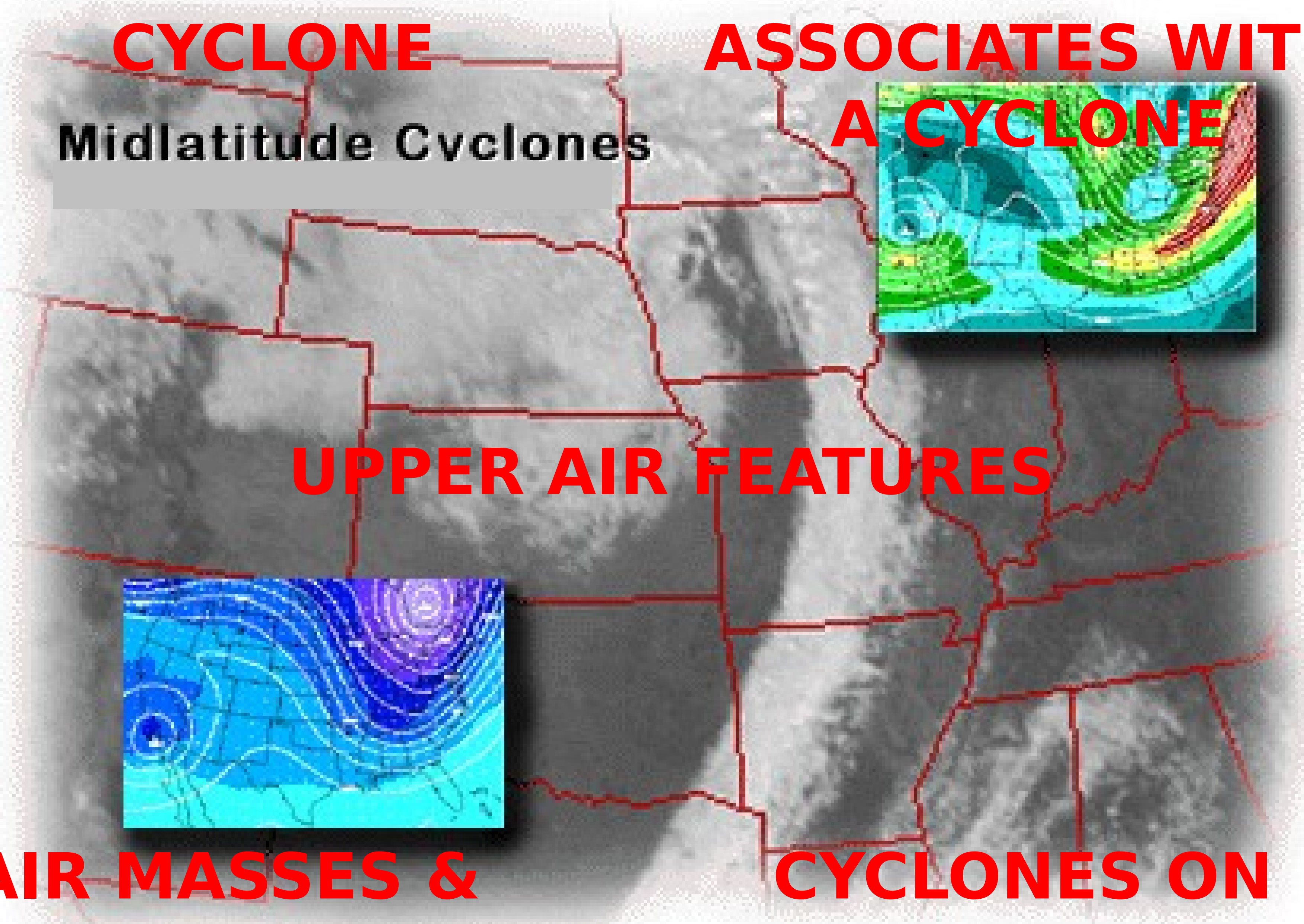
DEFINITION OF A CYCLONE

WINDS ASSOCIATES WITH A CYCLONE



UPPER AIR FEATURES

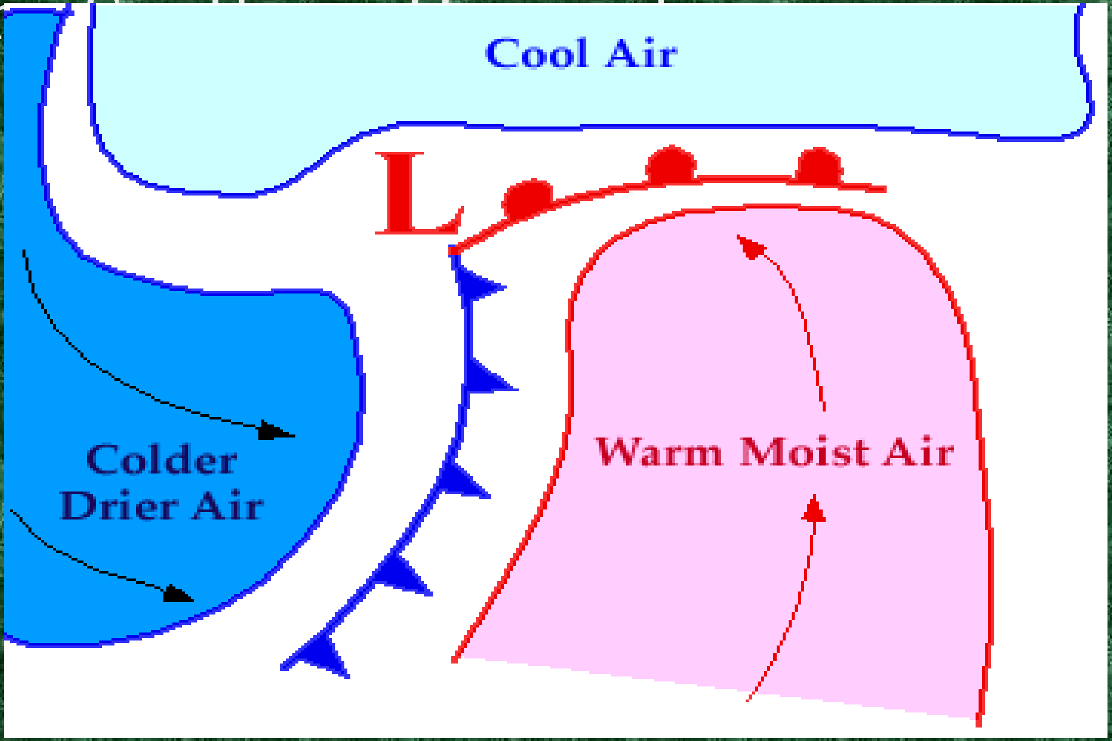
AIR MASSES & CYCLONES

CYCLONES ON SATELLITE IMAGES

Cyclones

an idealized model

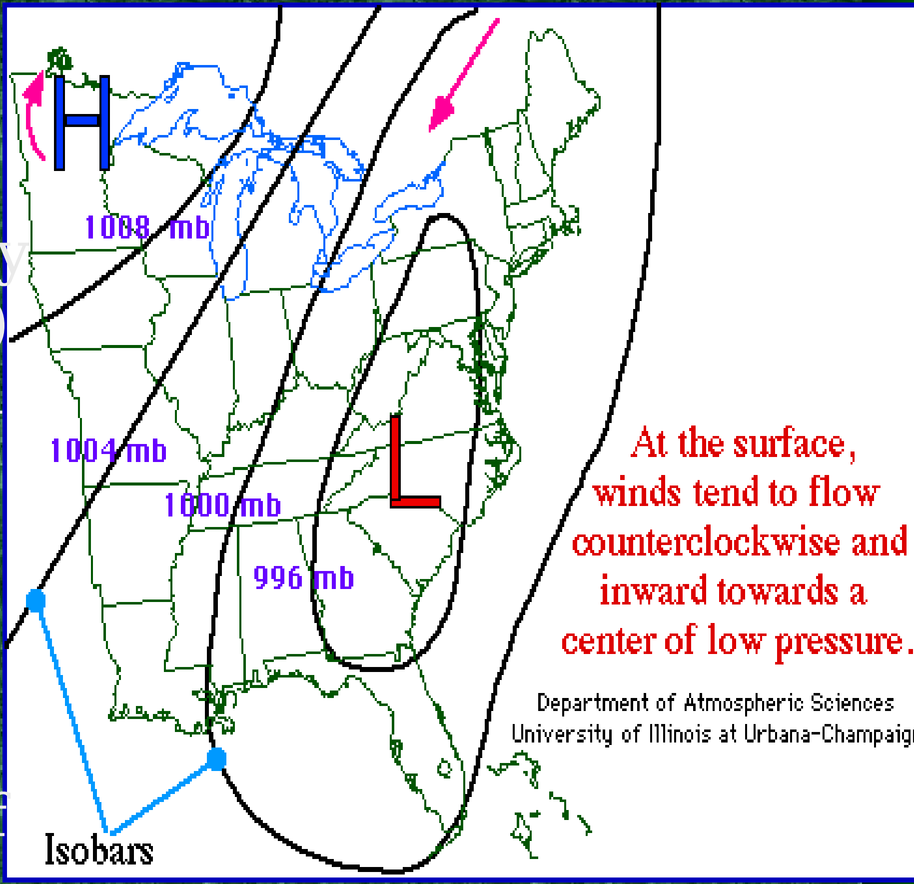
A cyclone is an area of low pressure around which the winds flow counterclockwise in the Northern Hemisphere and clockwise in th



A developing cyclone is typically accompanied by a warm front pushing northward and a cold front pulling southward, marking the leading edges of air masses being wrapped around a center of low pressure, or the

The counterclockwise winds associated with northern hemisphere midlatitude cyclones play a significant role in the movement air masses, transporting warm moist air northward ahead of a low while dragging colder, drier air southward behind it.

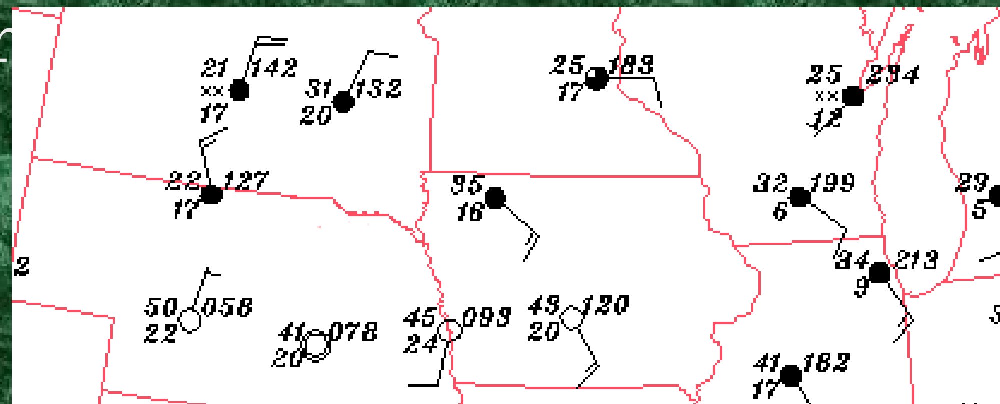
Rising air in the vicinity of a low pressure center favors the development of clouds and precipitation, which is why cloudy weather (and likely precipitation) are commonly associated with an area of low pressure. Cyclones are easily identifiable on certain types of weather maps by remembering some key signatures. For example, a cyclone can be found on a map of surface observations by recognizing a counterclockwise rotation of the



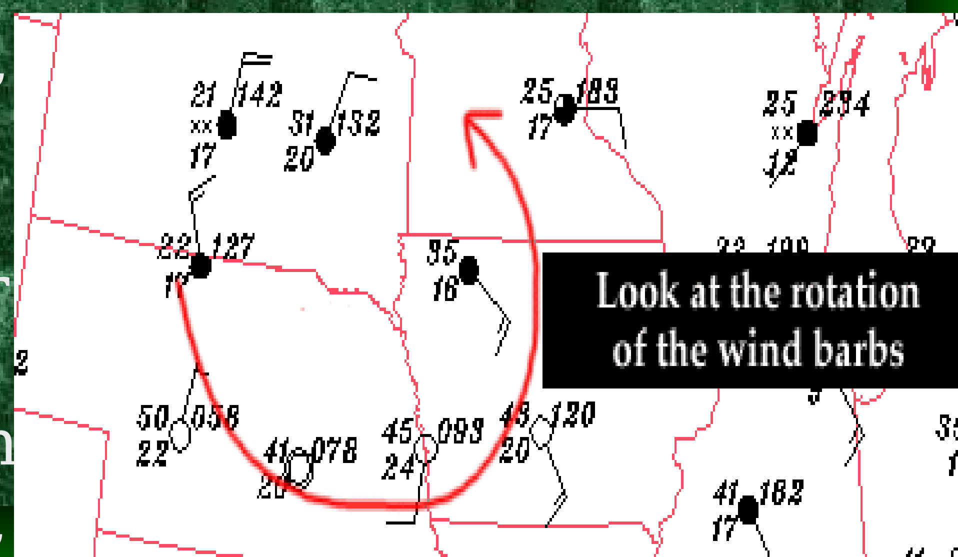
Winds Around Cyclones

flowing counterclockwise in the northern hemisphere

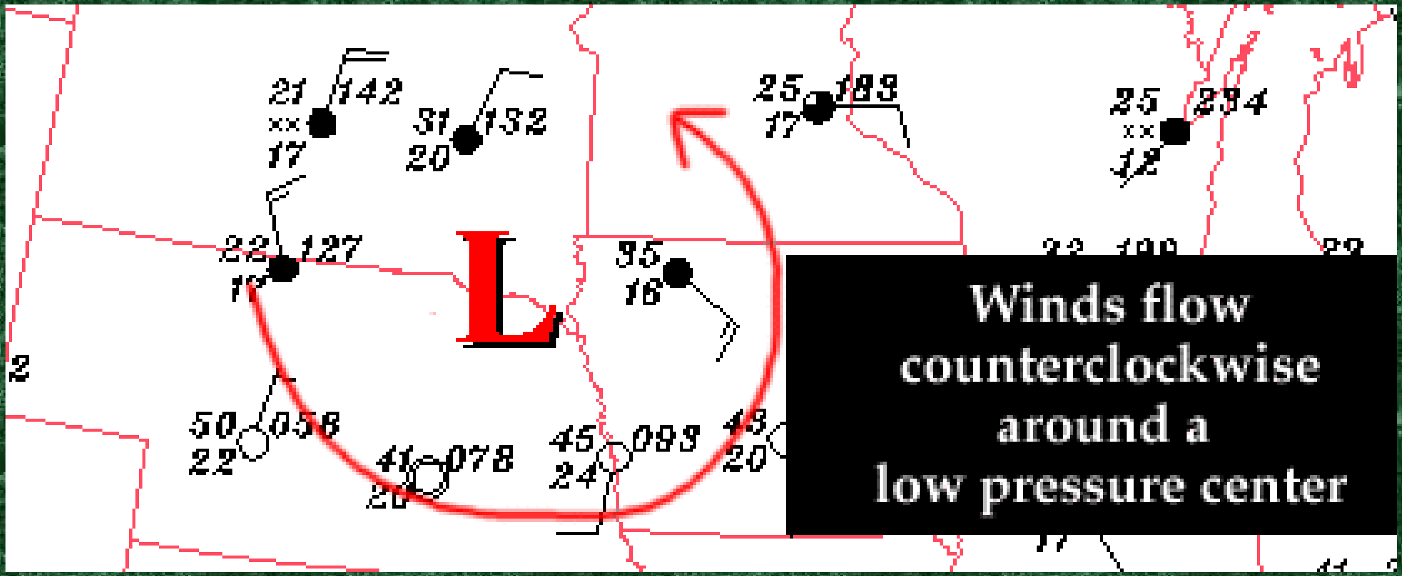
Wind barbs are useful for locating low pressure centers on surface weather



Since winds flow in a counterclockwise direction around low pressure centers, look for a group of stations where the wind barbs reflect this type of wind pattern. For example, a counterclockwise wind pattern was observed in the states of Nebraska, Iowa,



The low pressure center was located near the center (similar to the center of a whirlpool) with winds flowing counterclockwise around it.

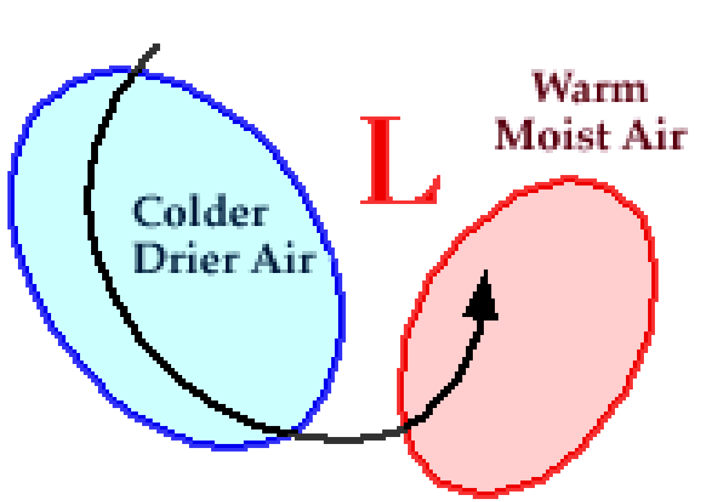


So when trying to find a low pressure center on a surface weather map, use the wind barbs to identify a counterclockwise wind pattern and the low pressure center will be found near the center of circulation.

The Movement of Air Masses

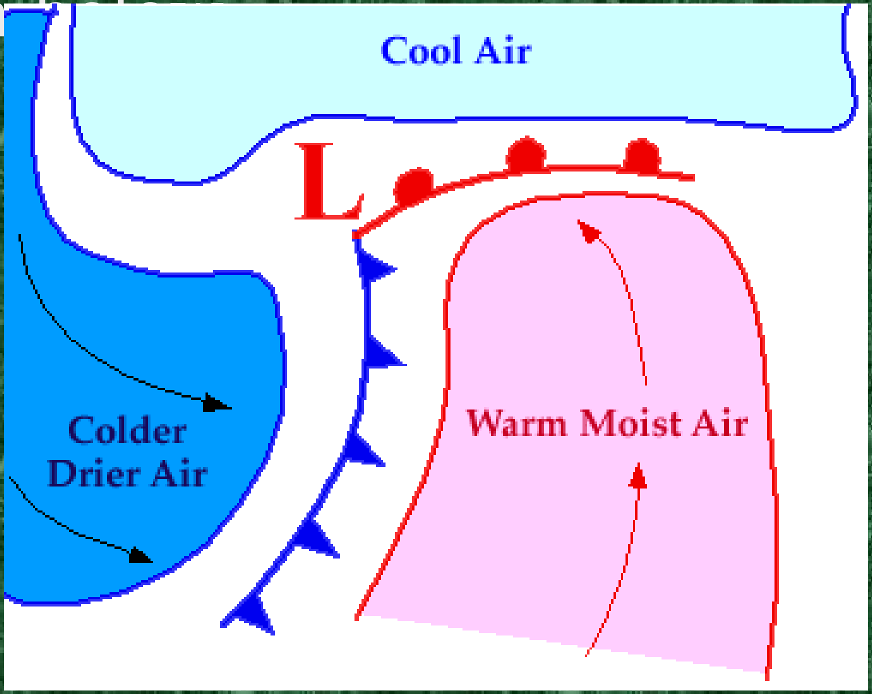
transporting warm air northward and colder air southward

Counterclockwise winds associated with cyclones transport heat and moisture from lower to higher latitudes and play a significant role in the movement of air masses.



As a cyclone intensifies, (the central pressure drops), counterclockwise winds around the low pressure center also intensify, transporting the air masses around the center of circulation.

By superimposing fronts over the low pressure center and the air masses, a top view of a midlatitude cyclone and accompanying air masses might resemble something like the diagram below.

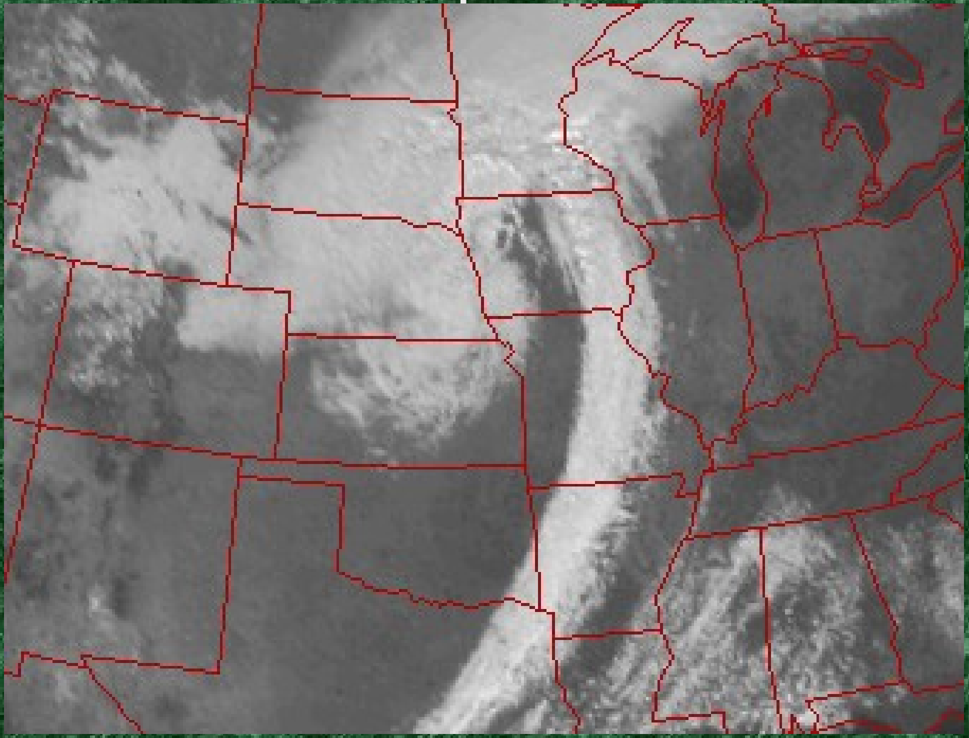


Southerly winds east of the low transport warm and moist air northward and this moisture often contributes to the development of precipitation. A warm front marks the leading edge of this warm, moist air mass. Behind the low, northerly winds transport colder and drier air southward, with a cold front marking the leading edge of

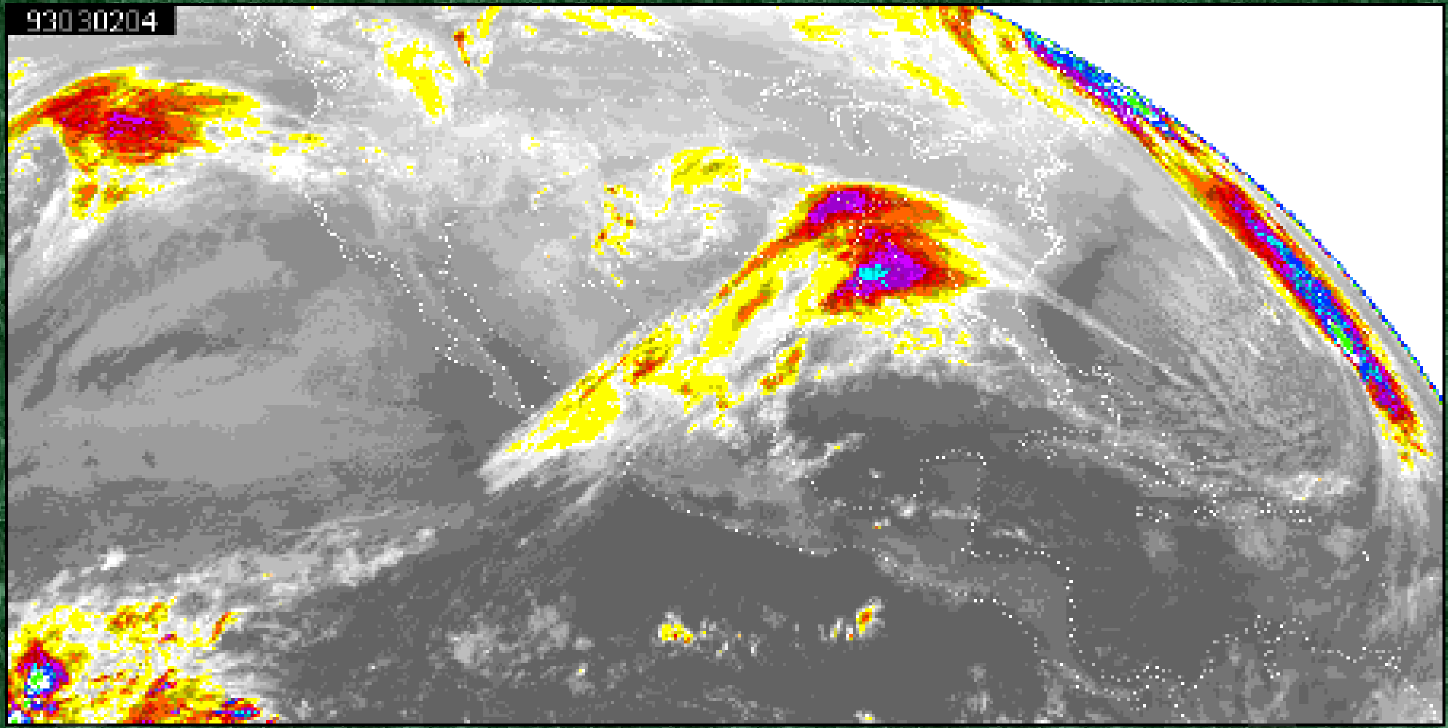
Cyclones on Satellite Images

comma-shaped cloud configuration

On satellite images, a midlatitude cyclone is often identifiable by a comma-shaped cloud mass



A single cyclone can influence the weather over a large area, (in this case from Texas into Minnesota). This particular storm (in the satellite image above) left more than six inches of snow from Nebraska into Minnesota, while heavy rains occurred from Missouri into Texas.

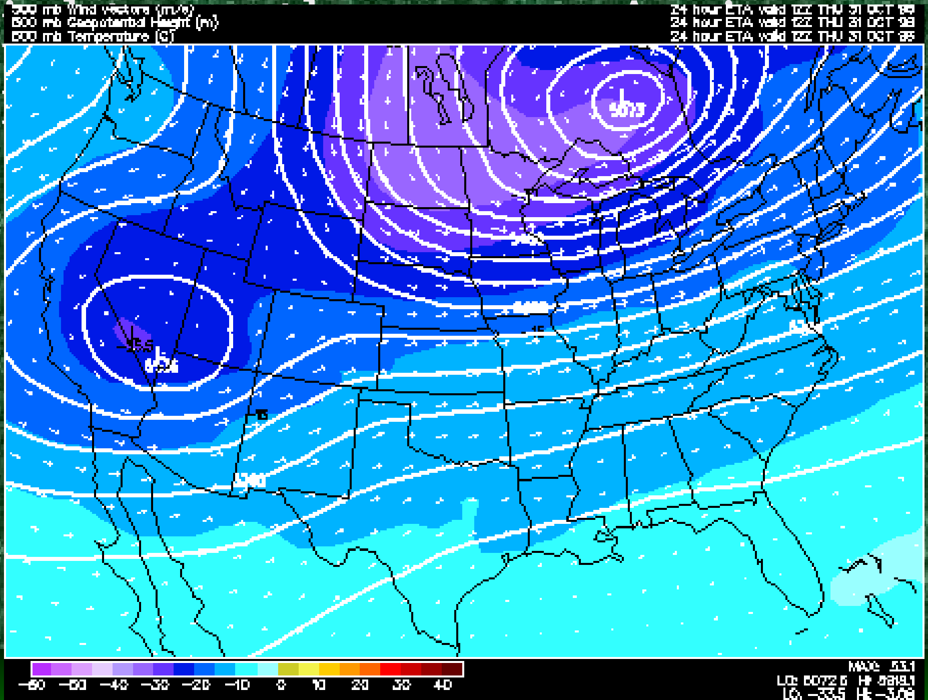


The center of the cyclone was initially located over the southcentral portions of the United States. As the cyclone evolved over time, notice the counterclockwise rotation of clouds around the cyclone center.

Geopotential Height

height of a given pressure

Geopotential height approximates the actual height of a pressure surface above mean sea-level. Therefore, a geopotential height observation represents the height of the pressure surface on which the observation was taken. A line drawn on a weather map connecting points of equal height (in meters) is called a height contour. That means, at every point along a given contour, the values of geopotential he … depicting the geopotential he…

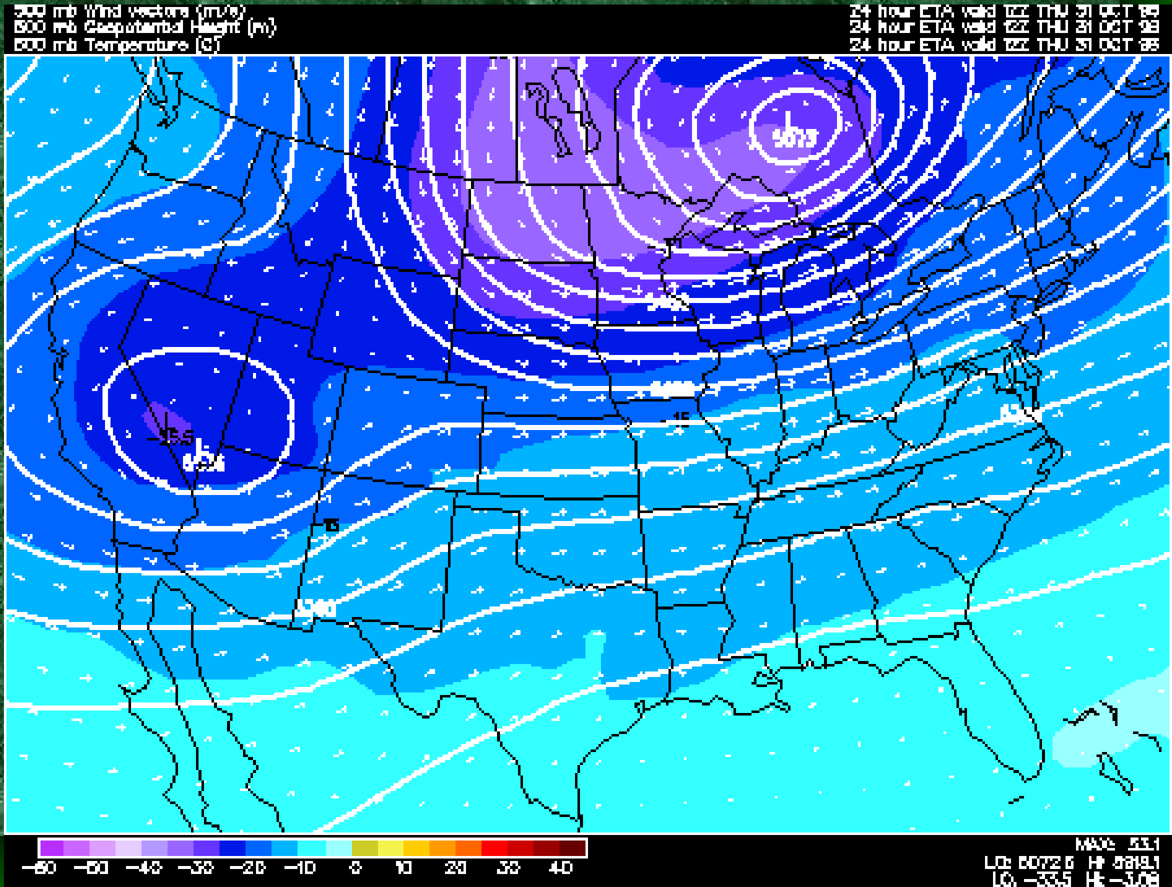


Height contours are represented by the solid lines. The small numbers along the contours are labels which identify the value of a particular height contour (for example 5640 meters, 5580 meters, etc.). This example depicts the 500 mb geopotential height field and temperatures (color filled regions). The height field is given in meters with an interval of 60 meters.

Geopotential height is

ridges which are the u

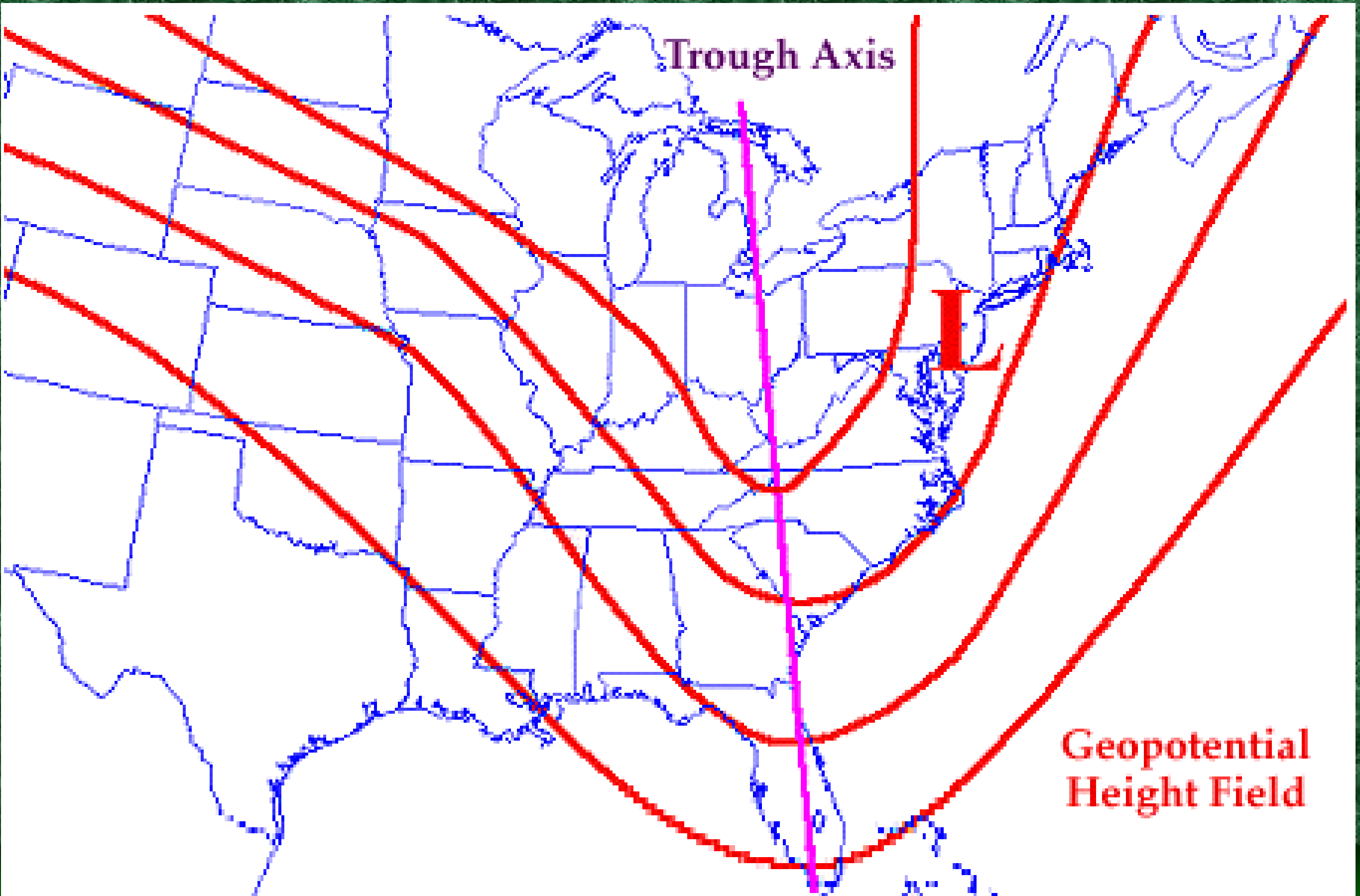
cyclones and anticyclo



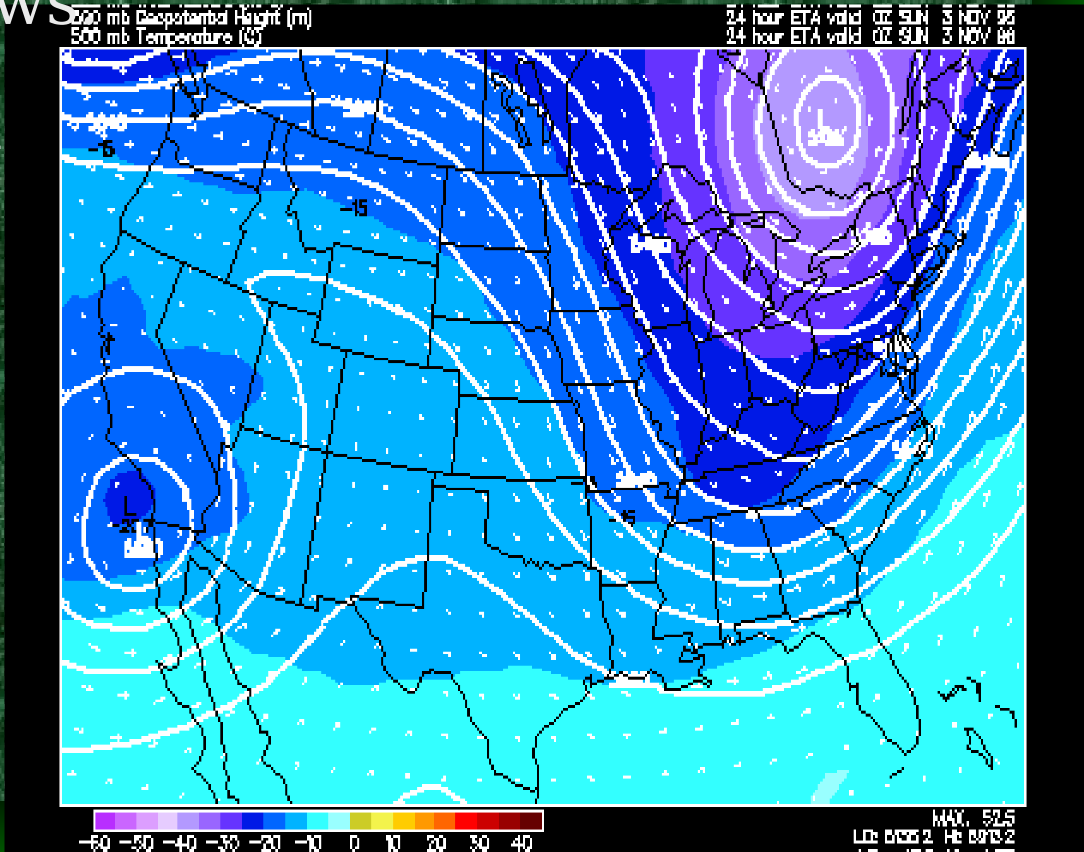
Troughs

upper level lows

When the height contours bend strongly to the south, (as in the diagram below), it is called a TROUGH. Strong troughs are typically preceded by stormy weather and colder air at the surface. Below is an example of a trough in an upper-level height field (red contours). The trough axis is de



The image below depicts geopotential height (solid white contours) and temperatures (colored regions) at 500 mb. Temperatures decrease with color from light blue to purple. A trough is located over the eastern United States and is indicated by the dip in the geopotential height field. This is the upper level extension of a surface low pressure center, which is why troughs are also called upper level lows.

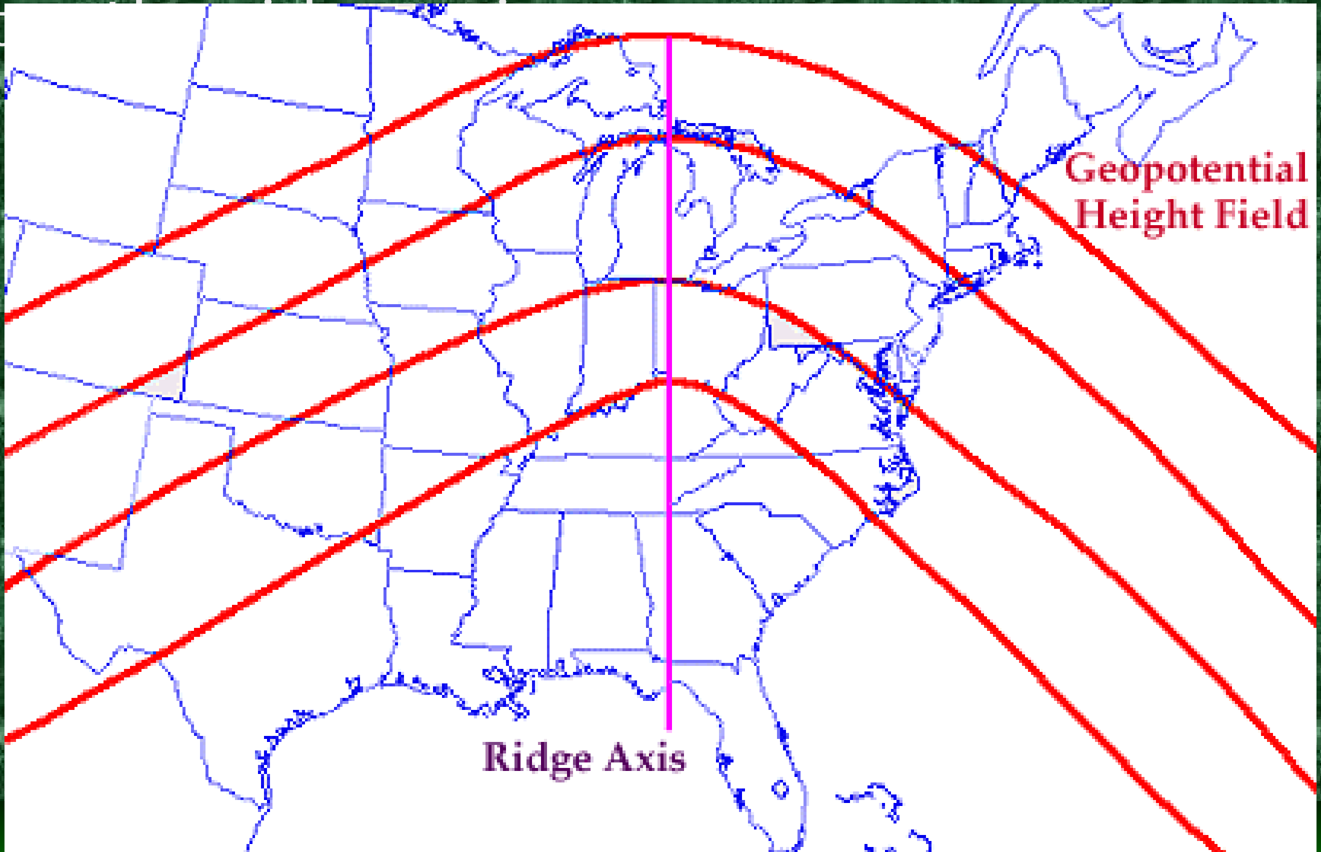


Notice the relatively cold temperatures associated with the trough. This is caused by the southward transport of colder air in the lower troposphere. The trough will intensify (deepen further southward) if cold air continues to move

Ridg es

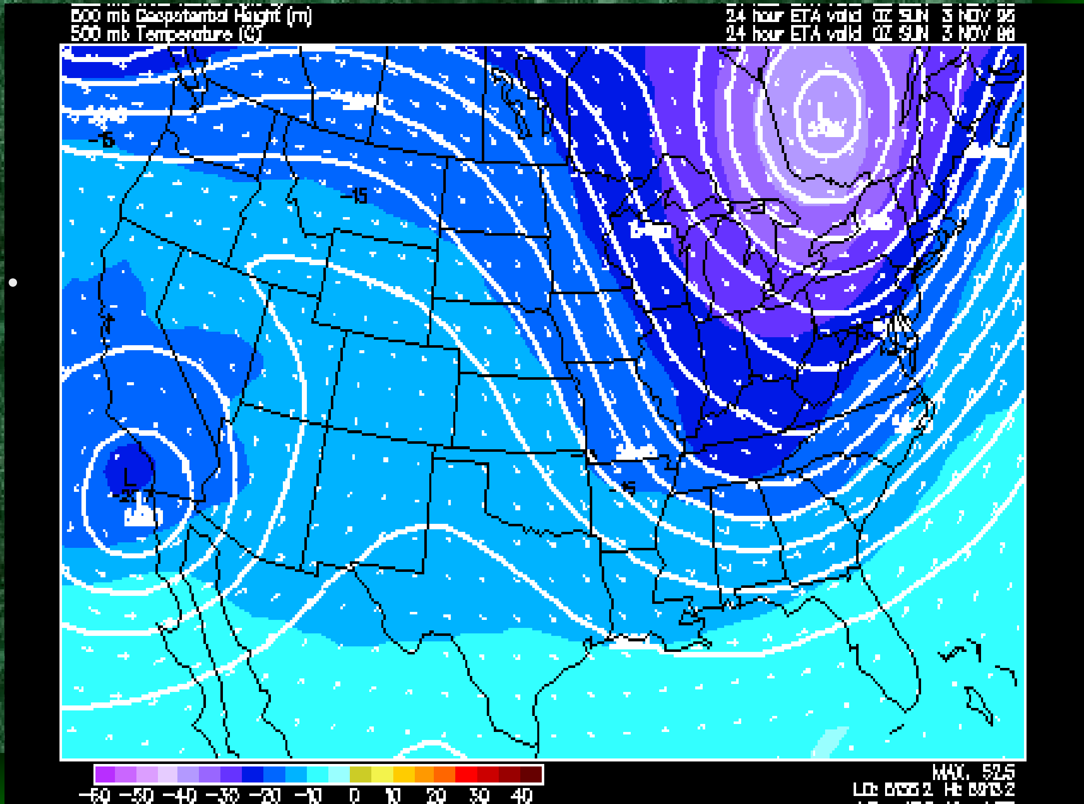
upper level highs

When the height contours bend strongly to the north (as in the diagram below), this is known as a RIDGE. Strong ridges are accompanied by warm and dry weather conditions at the surface. Below is an example of a ridge in an upper-level height field (red contours). The purple line denot



The image below depicts geopotential height (solid white contours) and temperatures (colored regions) at 500 mb. Temperatures decrease with color from light blue to purple. A ridge is located from Texas into Montana and is indicated by the bulge in the geopotential height field. This is the upper level extension of a surface high pressure center, which is why ridges are also called upper level highs.

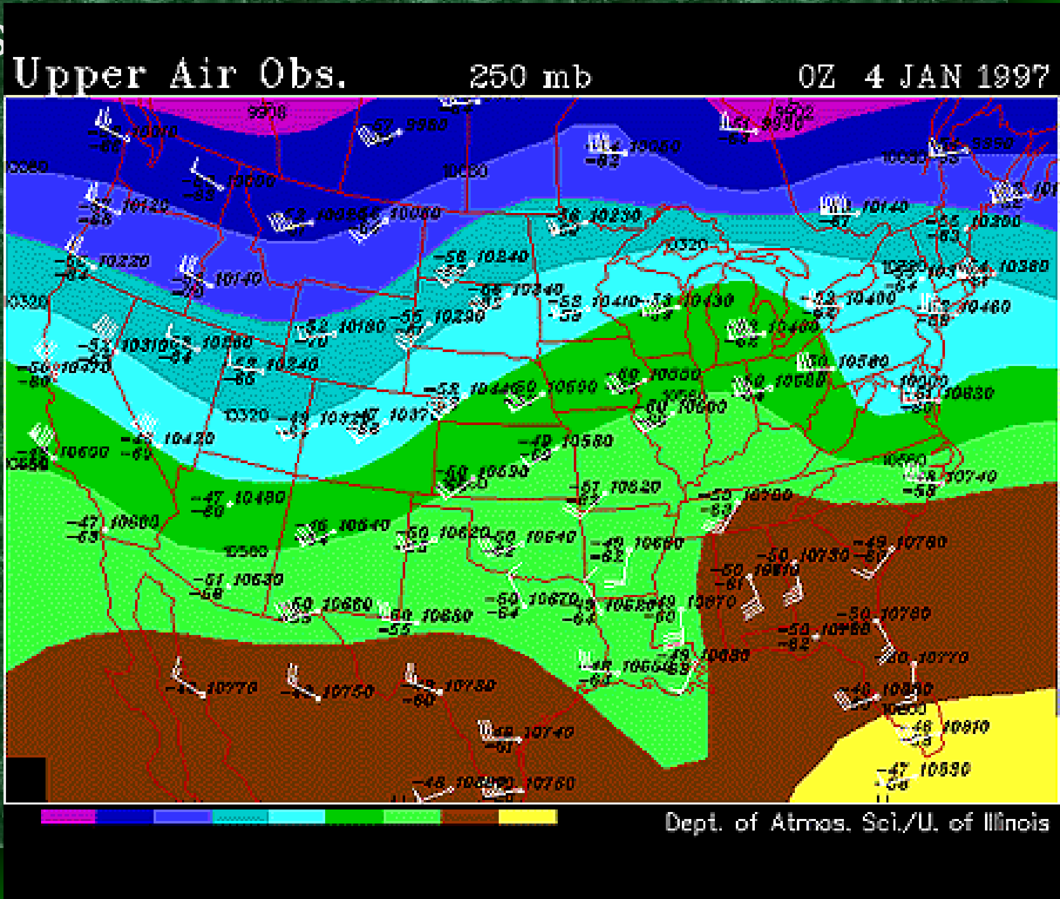
Notice the relatively warm temperatures associated with the ridge. This is caused by the northward transport of warmer air in the lower troposphere. The ridge will intensify (bulge further northward) if warm air continues to



Trough and Ridge Amplification

in response to lower level temperature advection

Warm advection beneath an upper level ridge causes it to build (increase in amplitude), while cold advection beneath an upper level trough will contribute to its deepening. The animation below highlights the amplification of ridge/trough system at 250 mb in response to intense thermal advection at 850 mb. The total time elaps



Observe how the ridge over the east gradually builds (raises northward) while the trough over the northern plains gradually deepens (sinks southward). While the entire ridge/trough system propagates eastward. Such amplification of upper level waves can increase the

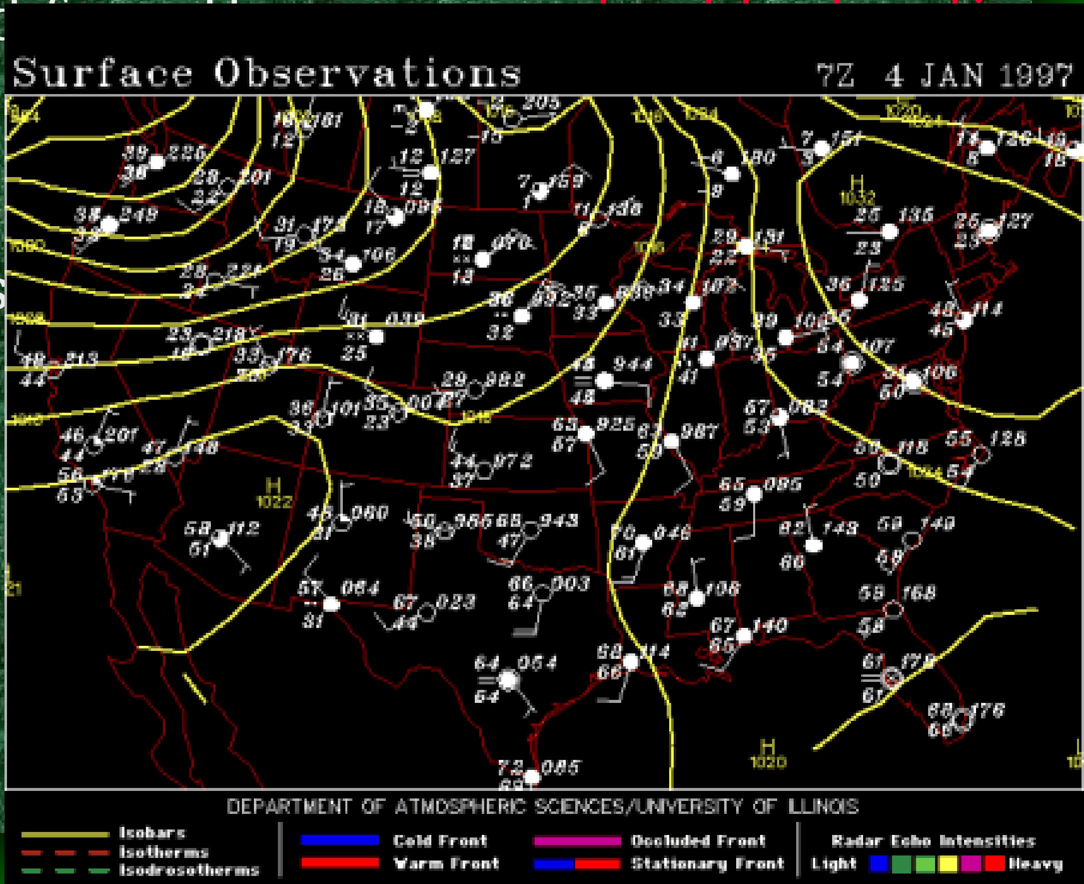
Rising Motion and Surface Pressure Falls

in response to warm and cold advections

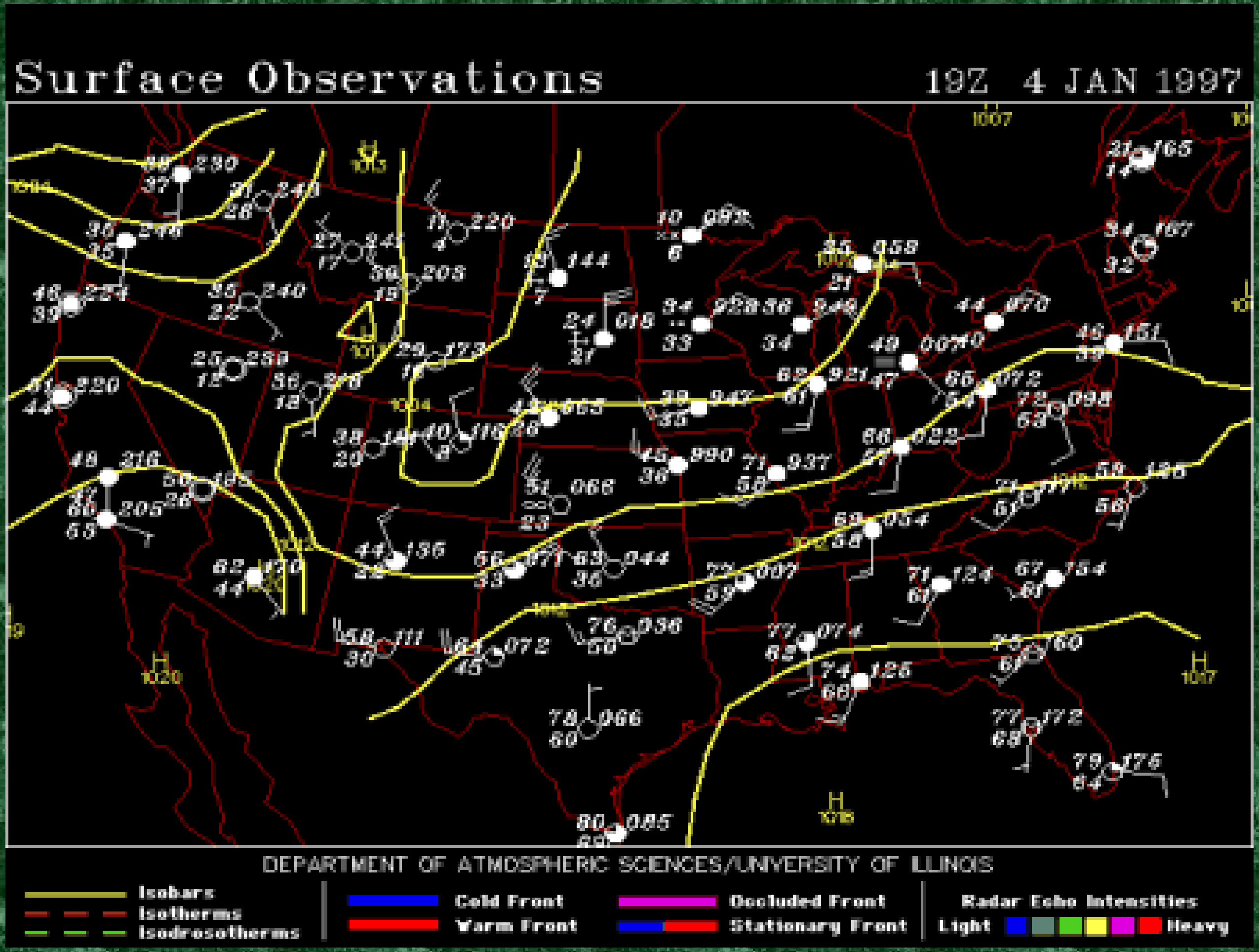
Warm and cold advection influence vertical air motion. Warm advection results in rising motion which leads to falling pressures at the surface, while cold advection leads to sinking motion, causing pressures to rise at the surface. The sequence of surface maps below show the surface pressure fields (isobars) that resulted

patterns at 850 mb.

The top map shows an area of low pressure over the northwestern United States and an area of high pressure over the eastern U.S. 12 hours later, there is a noticeable decrease in pressure from Texas to Illinois (region of strongest warm advection at 850 mb) while surface



A cyclone at the surface that moves under an area of warm advection at 850mb is likely to deepen. For this reason, systems at the surface will tend to "phase lock" with systems aloft, and they will propagate more or less together.

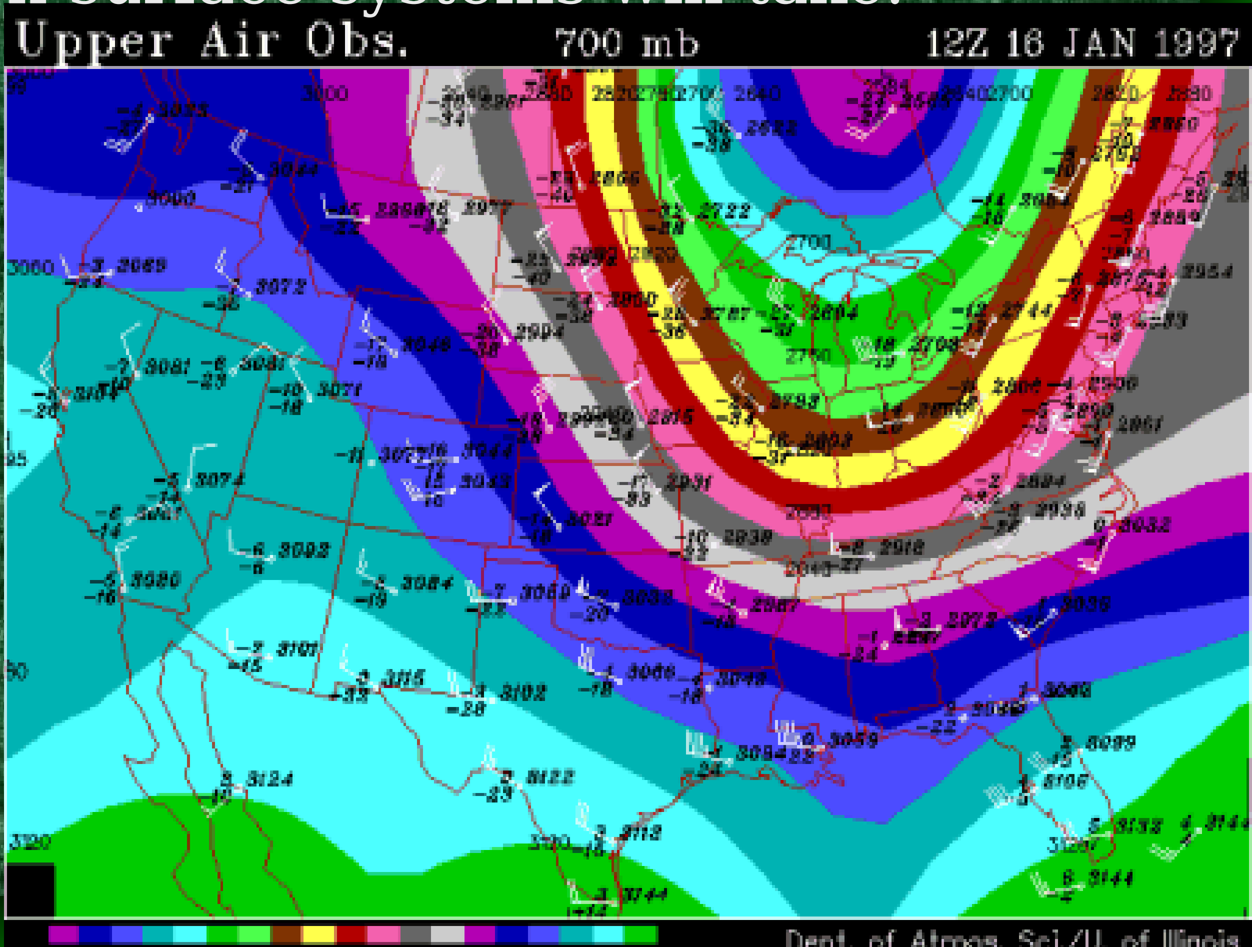


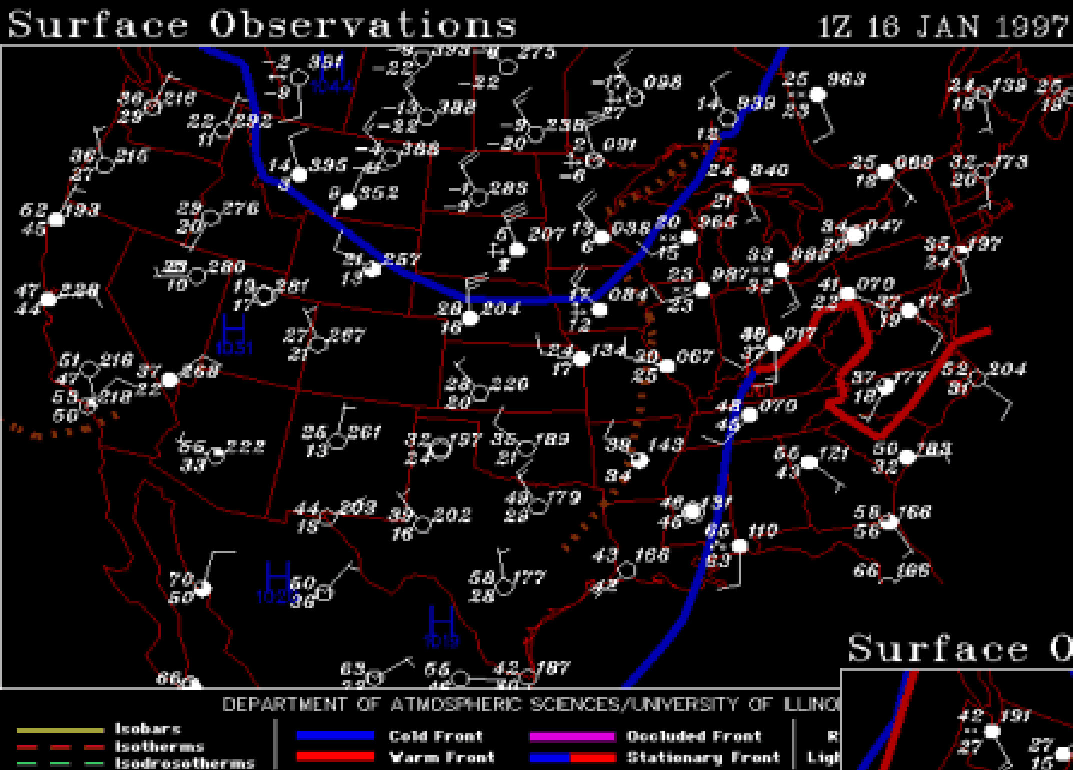
Steering Level For Cyclones

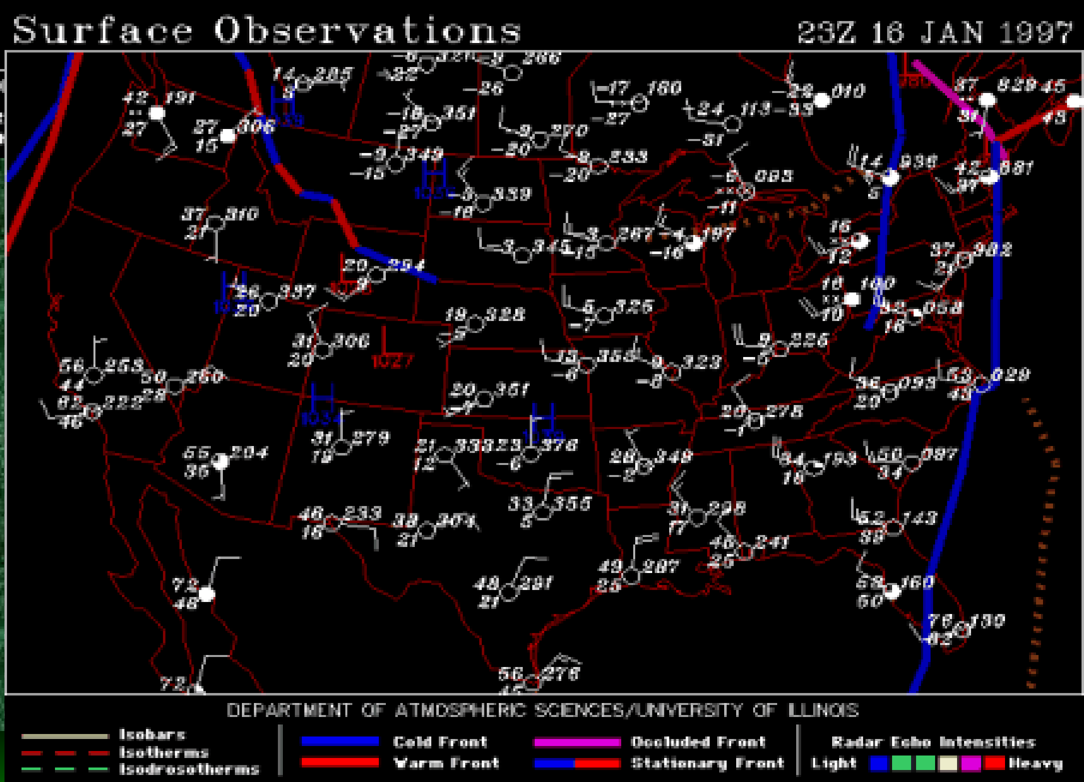
guided by winds near 700 mb

Surface systems often follow the prevailing airflow at this level. Therefore, the airflow at 700mb, inferred from the geopotential contours and geostrophic balance, can indicate the direction surface systems will take.

Notice that winds over the eastern U.S. are generally out of the south. At the same time, a surface cyclone was centered over the Ohio Valley.







24 hours later, the cyclone propagated northeastward (parallel to the winds at 700mb) and was centered over Eastern Canada.

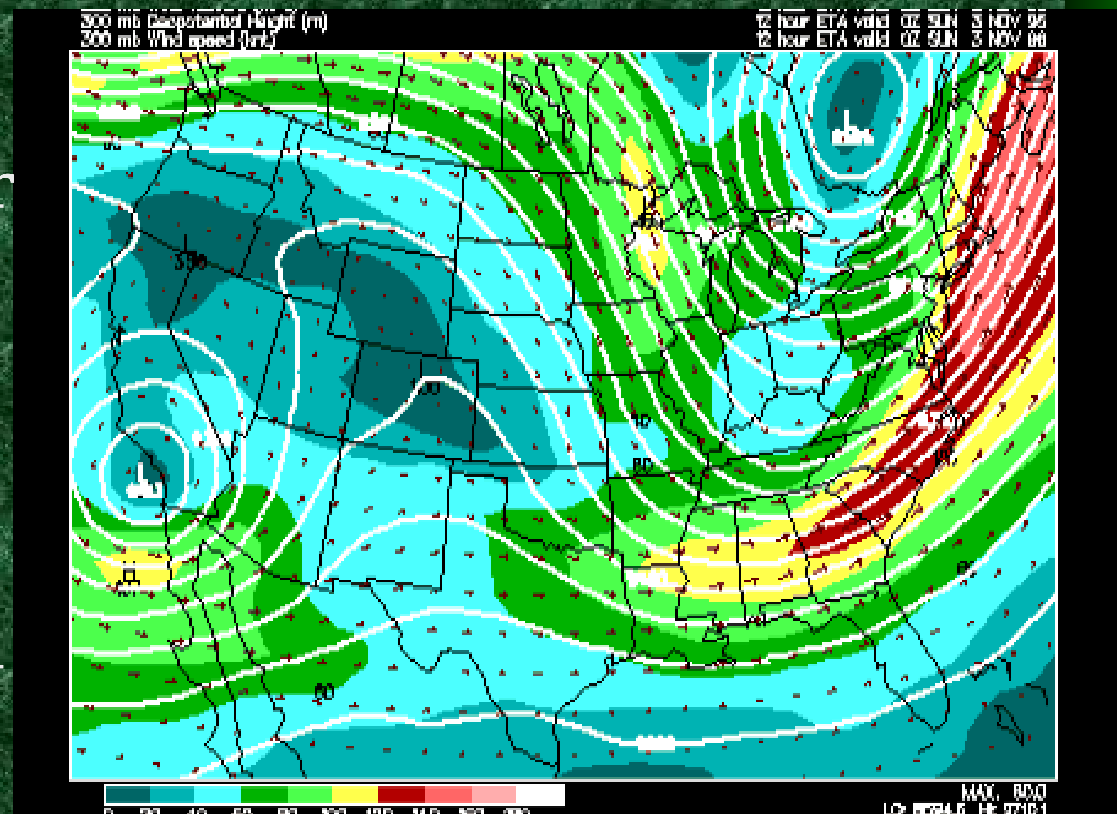
Jet Stream

current of rapidly moving air

The jet stream is a current of fast moving air found in the upper levels of the atmosphere. This rapid current is typically thousands of kilometers long, a few hundred kilometers wide, and only a few kilometers thick. Jet streams are usually found somewhere between 10-15 km (6-9 miles) above the earth's surface. The position of this upper-level jet stre
strongest SURFACI
diagram below).

During the winter months, Arctic and tropical air masses create a stronger surface temperature contrast resulting in a strong jet stream. However, during the summer months, when the surface temperature variation is less dramatic, the winds of the jet are weaker.

To the right is an ETA Model forecast panel for 300 mb winds and geopotential heights (white contours). The color filled regions indicate wind speed in knots and is color coded according to the legend at the bottom of the image. The shades of blue indicate winds less

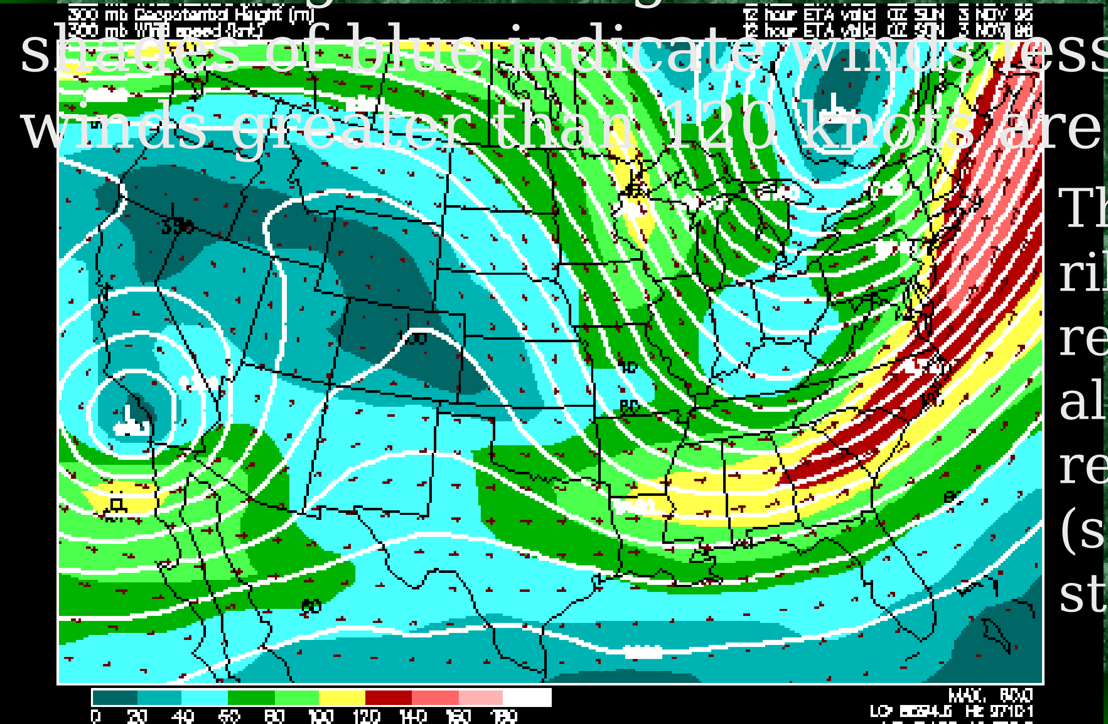


The yellow, green and red ribbon on the image above represents the jet stream, and along the East Coast, the region of strongest winds (shaded in red) is a

Jet Streaks

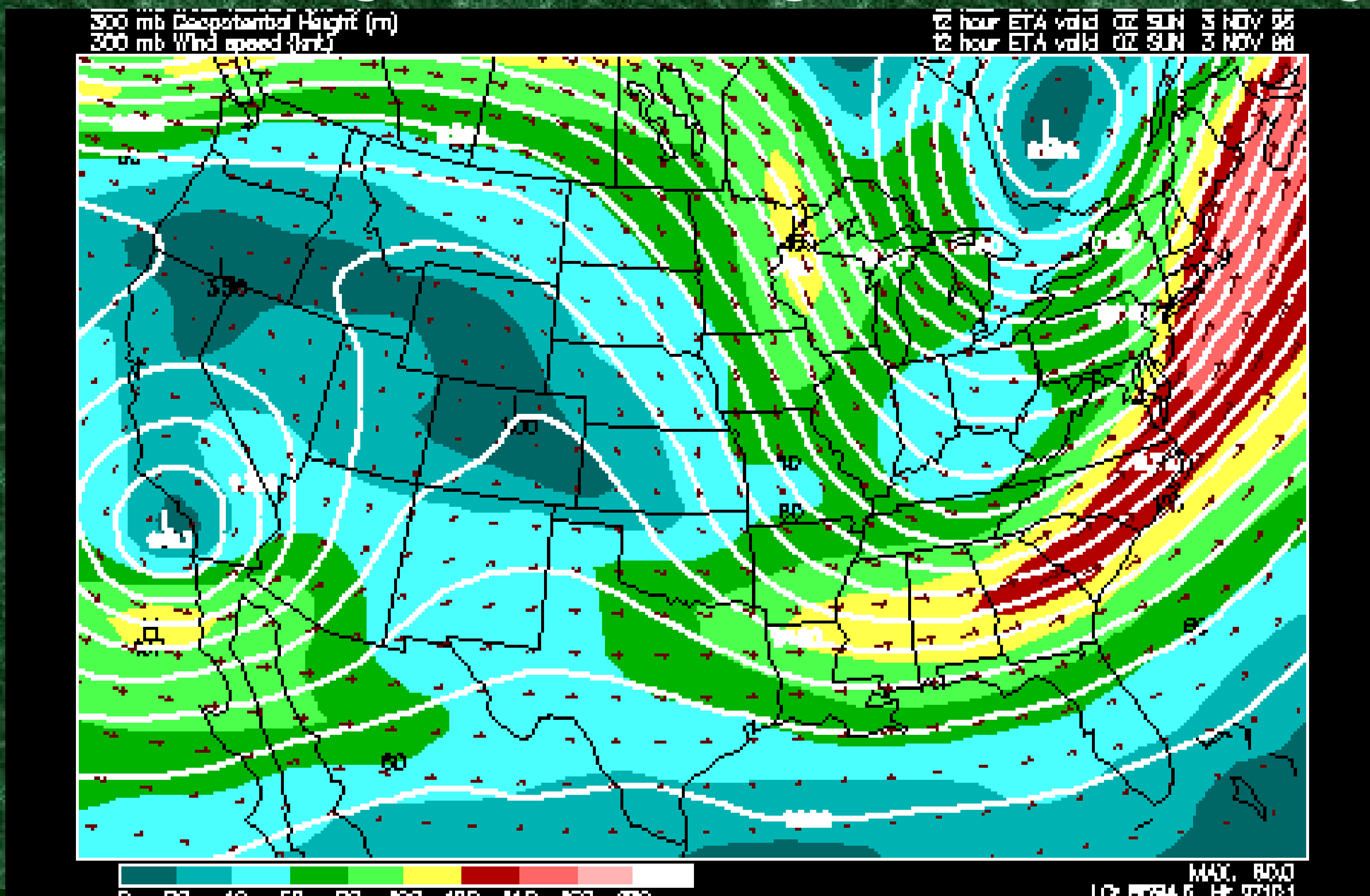
wind speed maxima within the jet stream

Jet streaks are localized regions of very fast winds embedded within the jet stream. Sometimes these local wind maxima reach speeds in excess of 160 knots. Below is an ETA Model forecast panel for 300 mb winds and geopotential heights (white contours). The color filled regions indicate wind speed in knots and is color coded according to the legend at the bottom of the image. The shades of blue indicate winds less than 60 knots, while winds greater than 120 knots are given in shades of red.



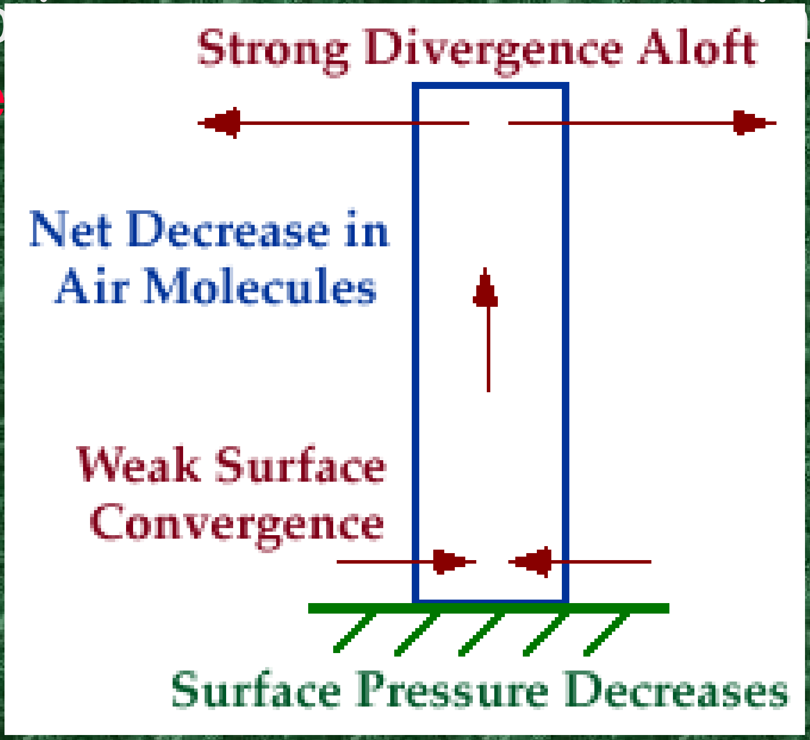
The yellow, green and red ribbon on the image above represent the jet stream, and along the East Coast, the region of strongest winds (shaded in red) is a jet streak.

As air enters a jet streak, it speeds up. When it leaves a jet streak, it slows down. These accelerations and decelerations, coupled with the curvature of the jet stream and strong wind shears, cause air to pile up in some areas (convergence) and spread out (divergence) in others. These regions of divergence and convergence have … features.



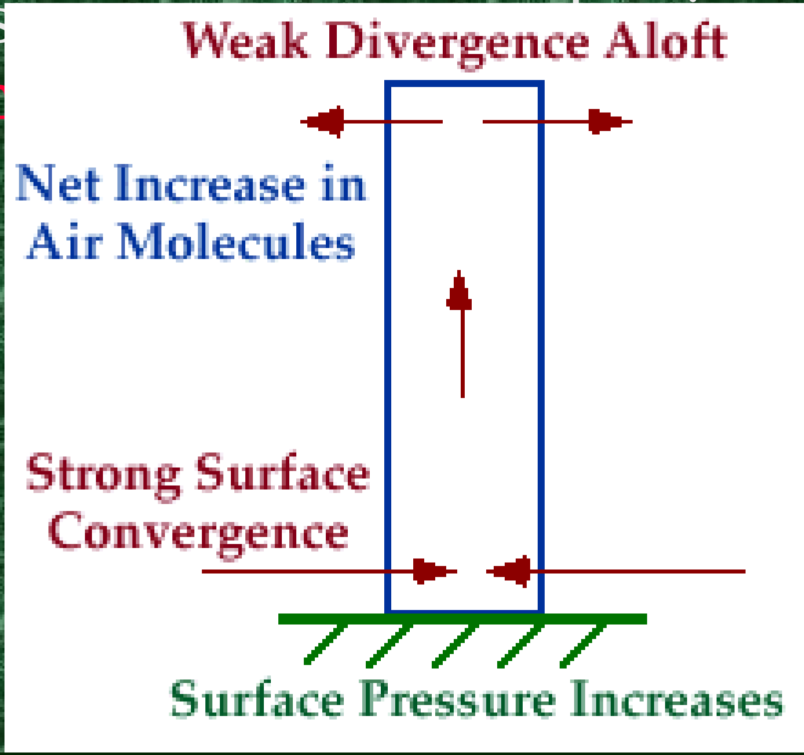
Intensifying Surface Cyclone:

For example, if a region of diverging winds at upper levels is stronger than the converging winds of a suface low pressure center below it, the low will deepen (intensify). This is because more air is being removed from the vertical column of air above the low than flowing into it, causing the pressure at the surface to decrease. A drop intensification of the low pressure



Weakening Surface Cyclone:

In contrast, if a region of diverging winds at upper levels is weaker than the converging winds of a suface low pressure center below it, the low begins to fill (weaken). This is because more air is flowing into the vertical column of air above the low than flowing out of it, causing the pressure at the surface to increase. An increase in press of the low pressure cen



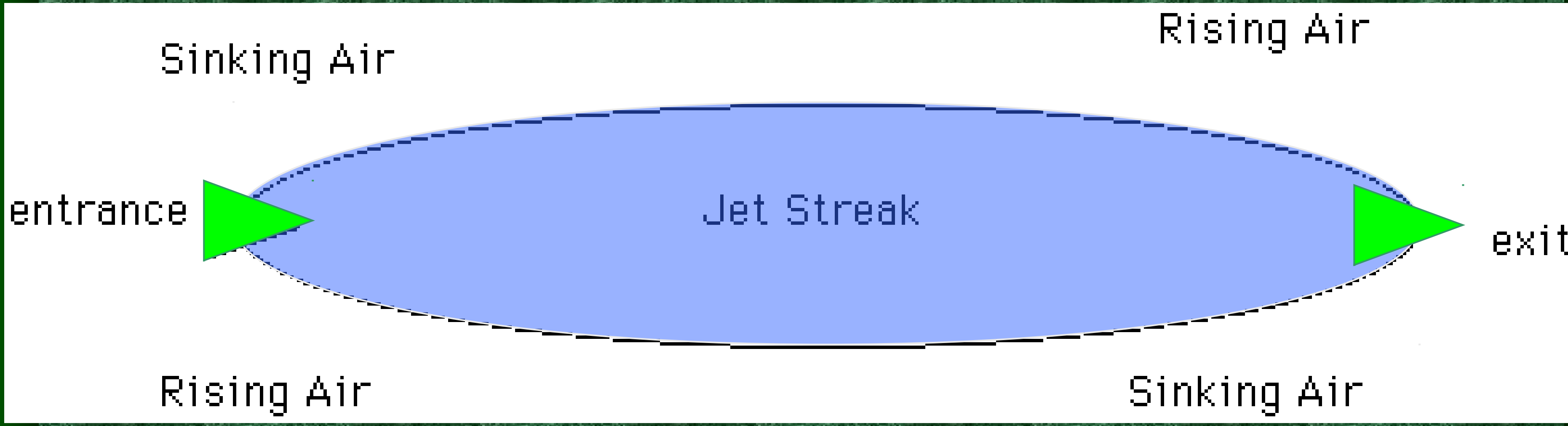
Vertical Motion and Jet Streaks

associated with different regions of a jet streak

Jet streaks are important as they are indicative of rising motion/falling pressures at the surface. The figure below represents an idealized jet streak.

Convergence Cops

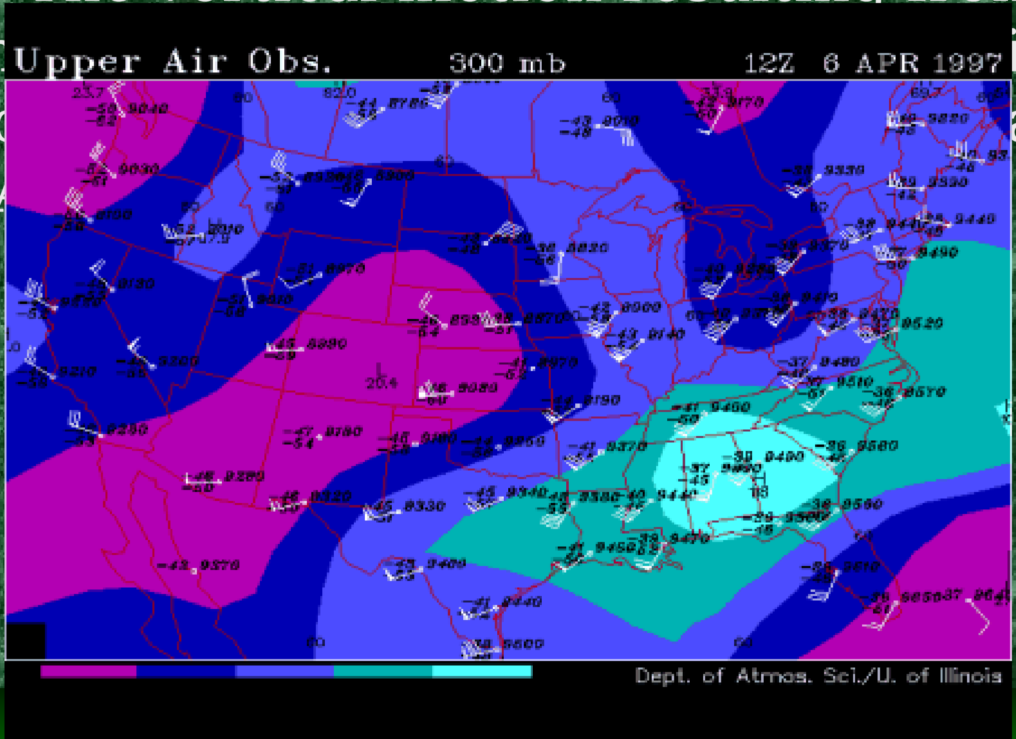
Divergence Don't



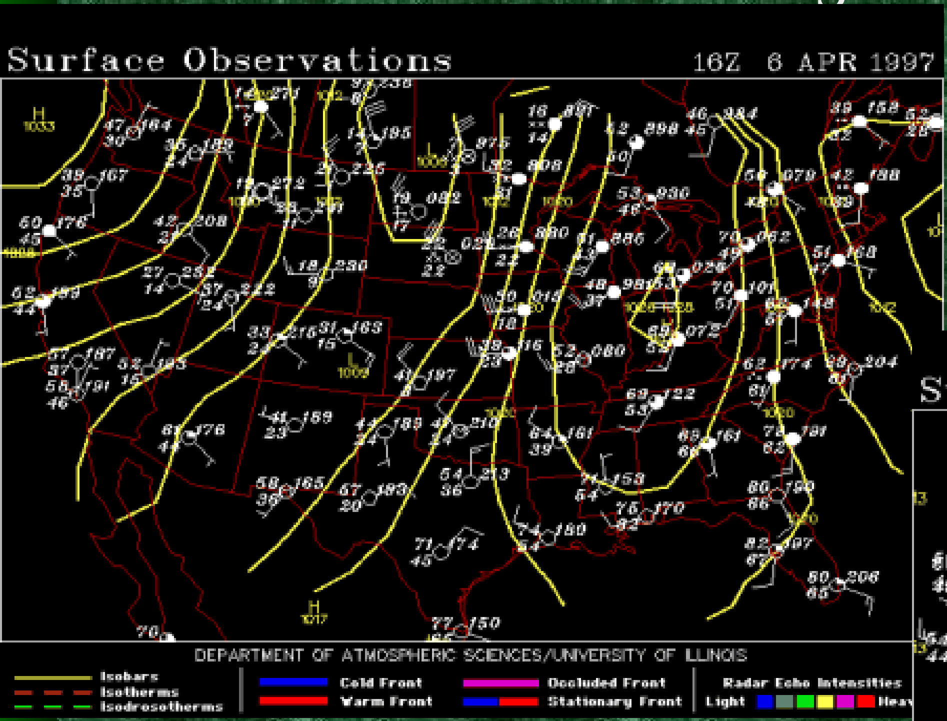
Do Divergence

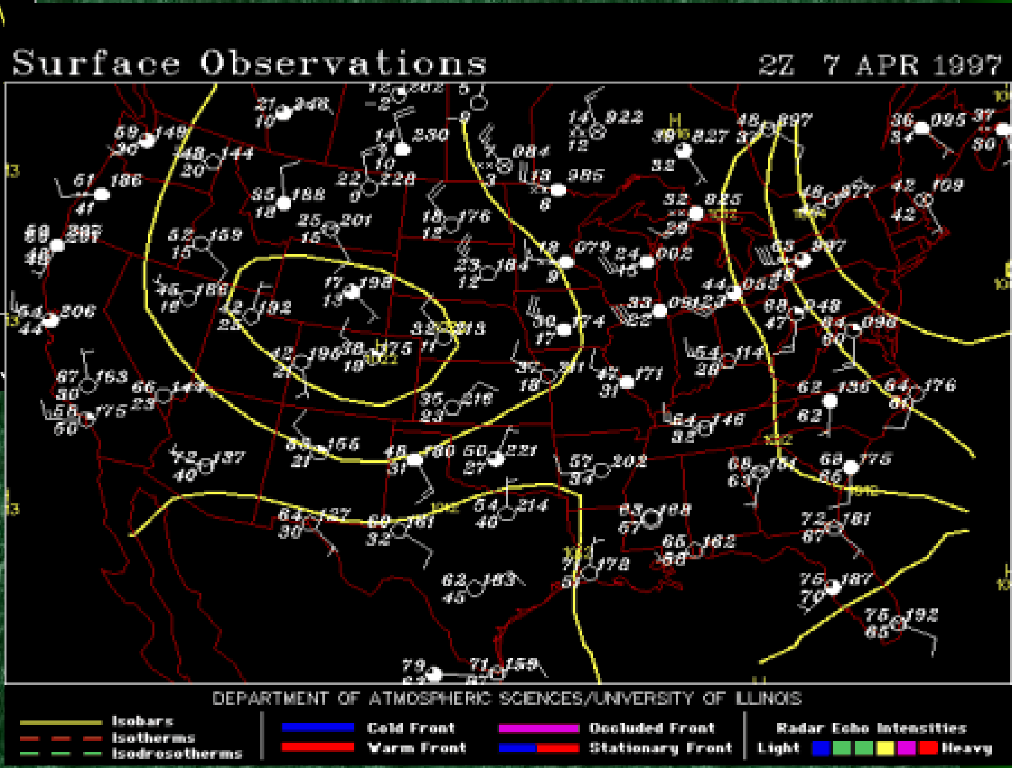
Cops Convergence

As air enters from the left, it must be accelerated. The force to do this is supplied by the Coriolis force as air flows from the south to the north near the jet entrance, leading to a force to the east (the right). This air motion results in a convergence to the north and a divergence to the south. As a result, air sinks in the northern 'quadrant', and rises in the southern quadrant, leading to pressure changes at the surface. In the jet exit region, the opposite happens, as air flows from north to south to create the force necessary to decelerate the air as it leave the jet streak. The vertical motion resulting from this leads to rising air in th in the south, also leading to at this 300mb map for 12Z, A



Notice the jet streak that lies along the southeastern U.S. Now look at the following surface pressure plots.





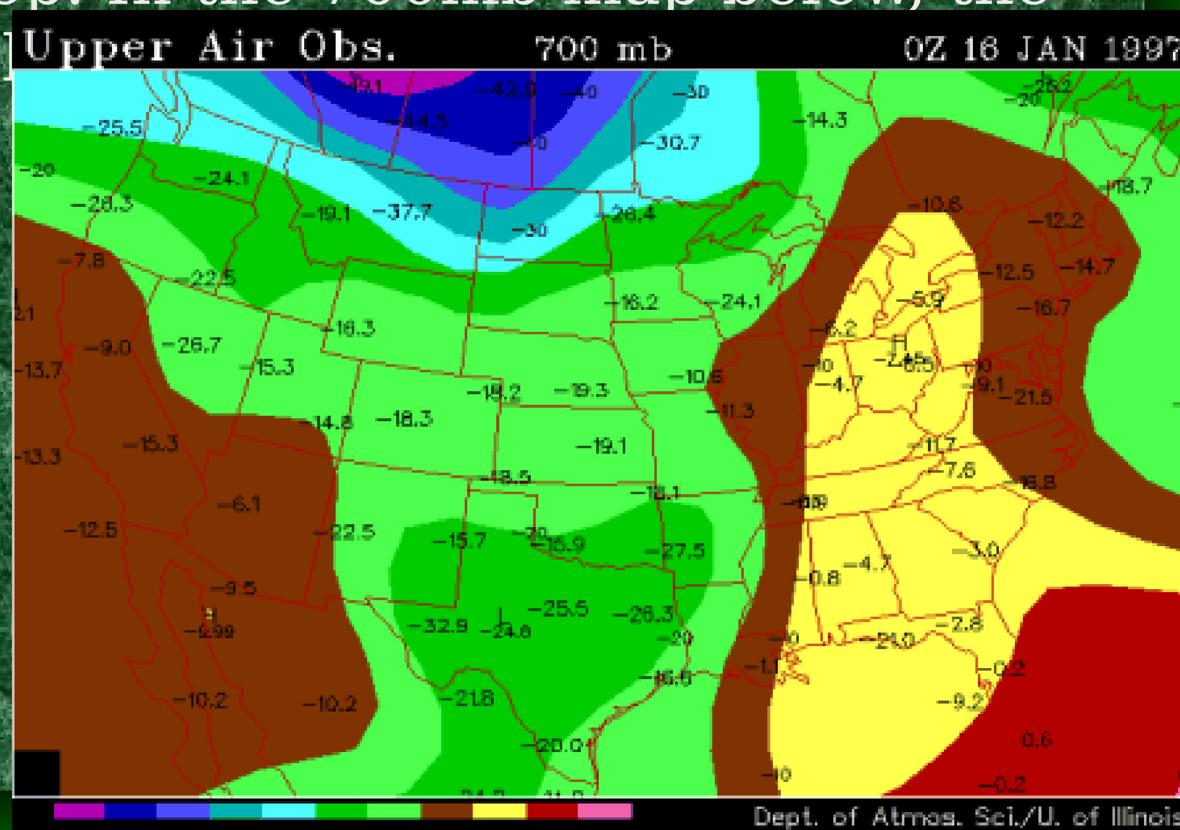
Notice how pressures have risen below the north entrance region, and fallen below the north exit region. This will intensify cyclones which tend to be located below the north exit quadrant.

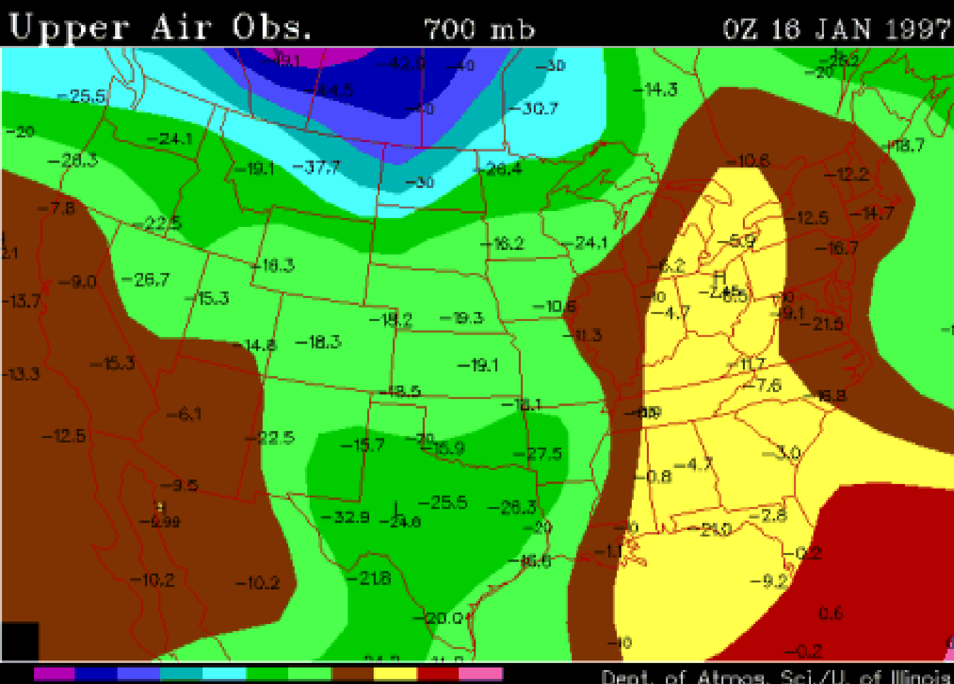
700 mb Dew Point Depression

important indicator for the presence of clouds

Dew point depression (DD) is useful indicator of how moist the air is and is calculated by taking the difference between the temperature of the air and the dew point temperature. Lower dew point depression values mean that the air is very moist, and an increased likelihood that clouds will develop. In the 700mb map below, the lowest DD values are l

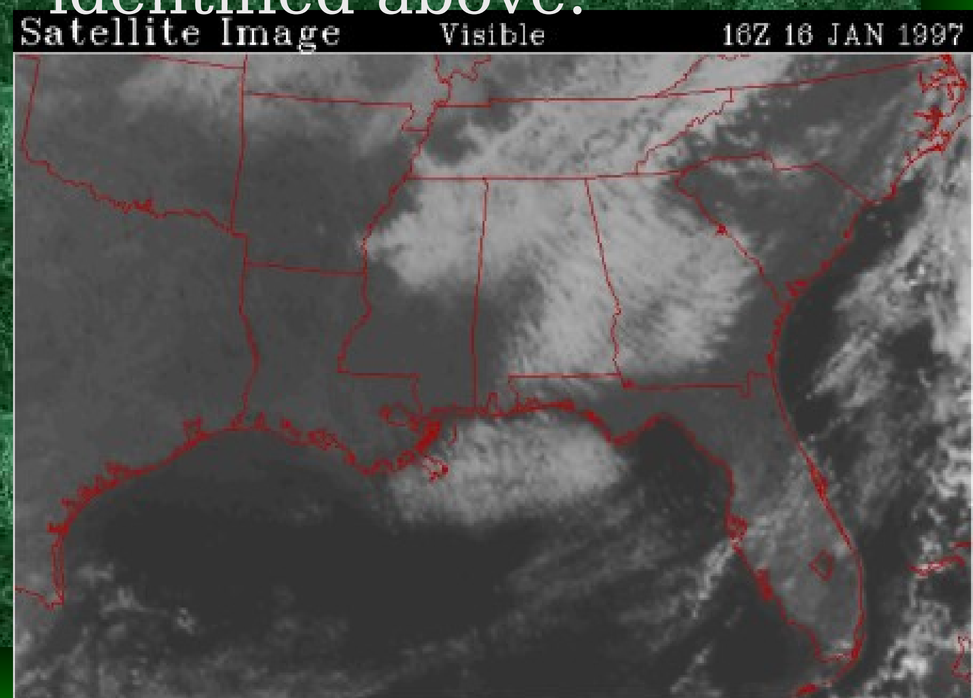
in yellow).





Examination of the visible satellite image from the same time reveals an extensive cloud deck present over the Southeast, corresponding very well with the low DD values identified above.

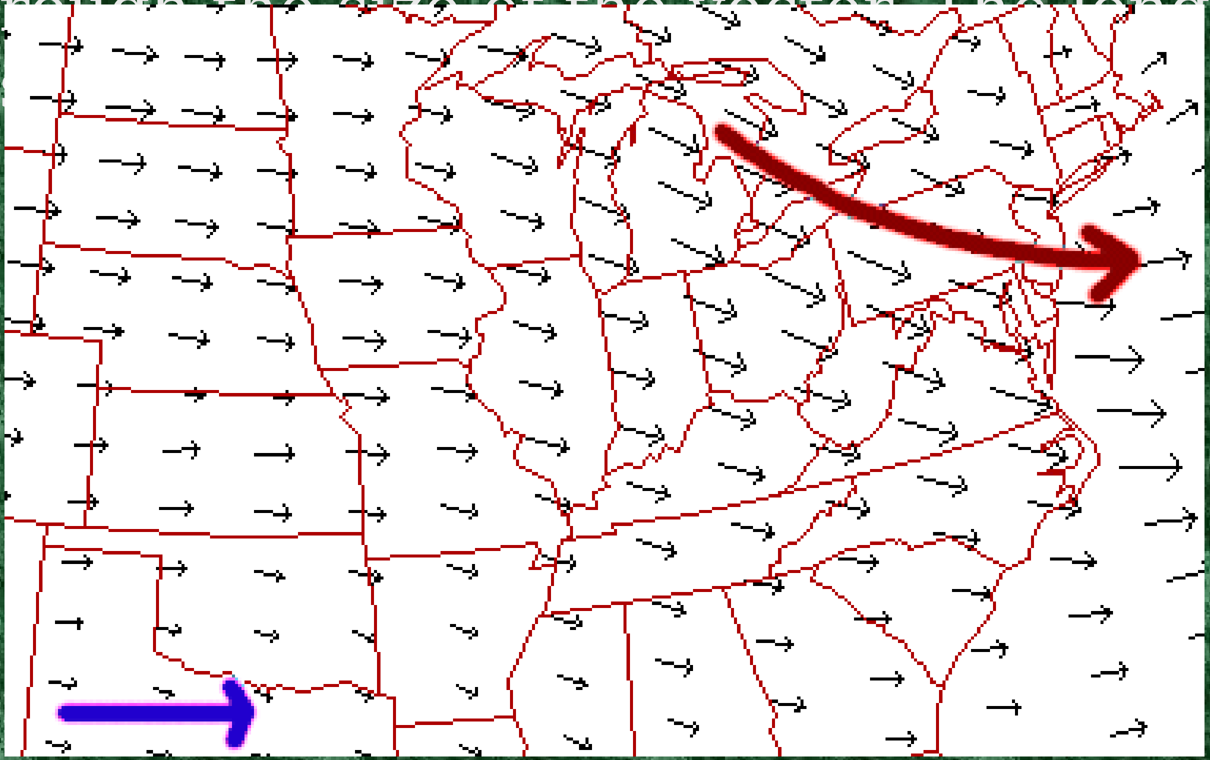
Also observe the lack of clouds over Texas and Louisiana, areas of much greater DD, indicating drier air.

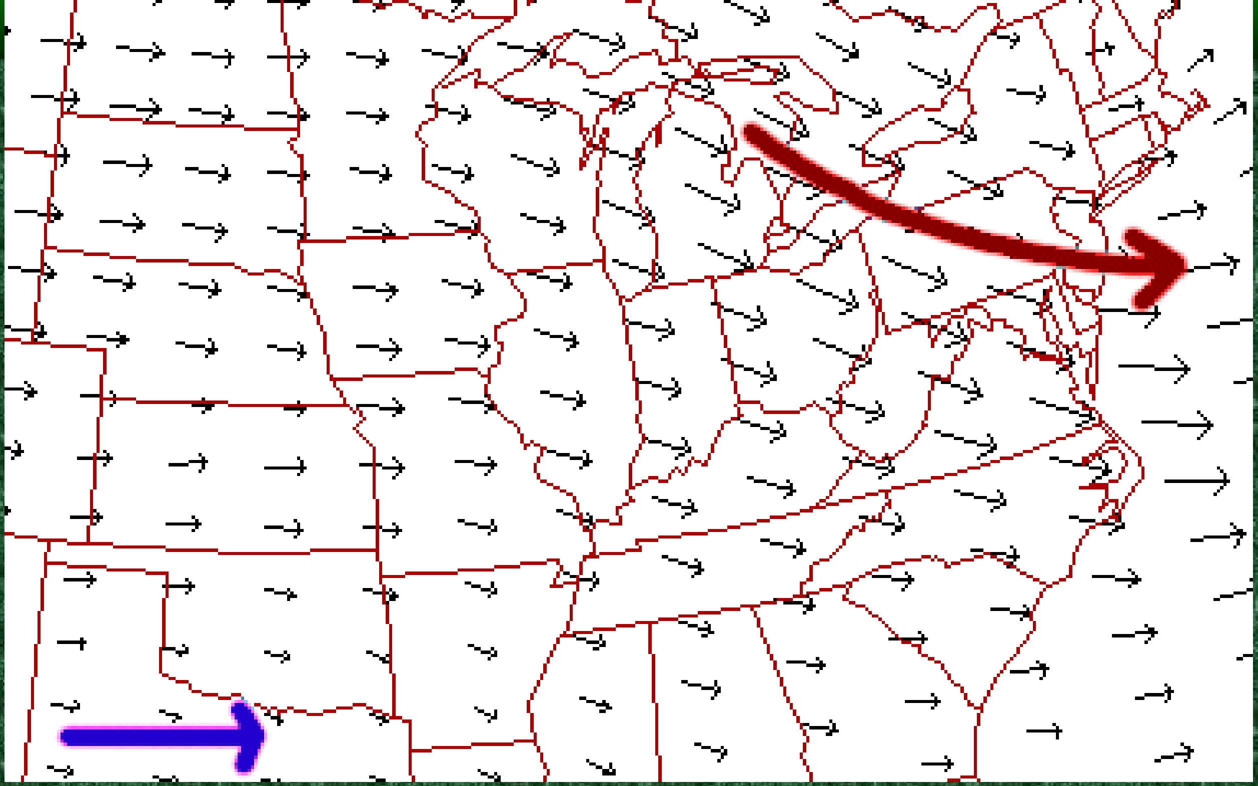


Wind Vectors

indicate wind direction and speed

The black arrows plotted on this image are wind vectors. These vectors indicate direction and intensity of the wind. The vectors point in the direction to which the wind is blowing and in this image, winds are primarily blowing from west to east. Intensity of the wind is conveyed thr… The longer the arrows, the s…

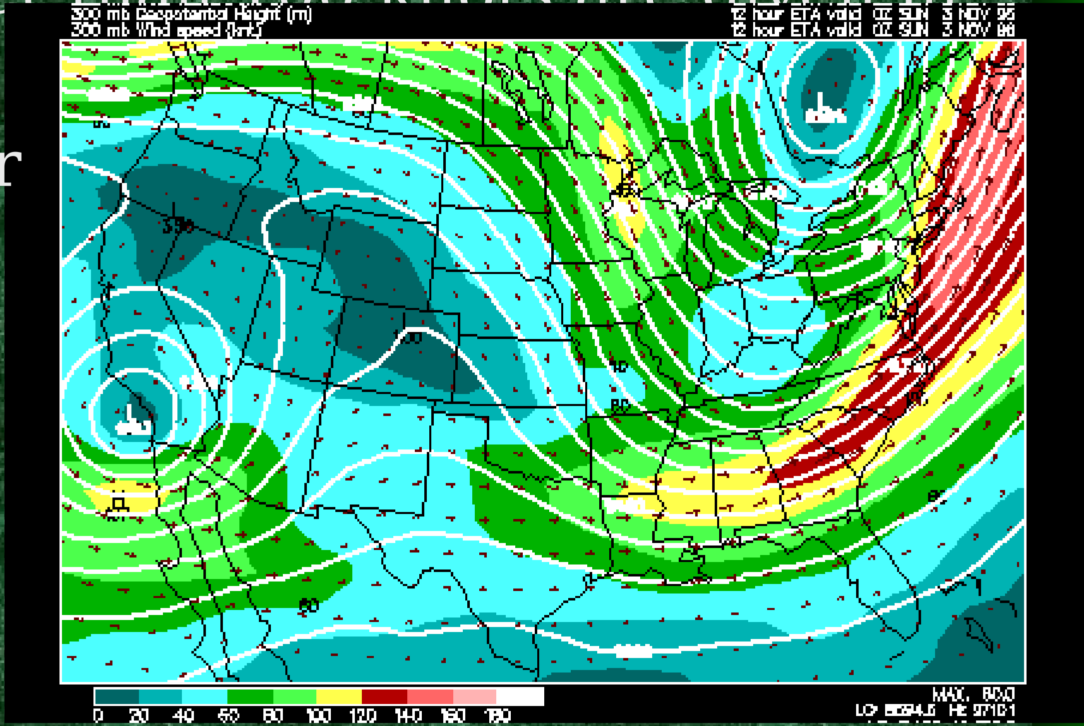




For example, wind vectors in the vicinity of the red arrow are longer than those near the blue arrow. This means that by the red arrow, the winds are stronger, than by the blue arrow. Wind vectors are also useful in finding regions of upper level convergence and divergence, which indicate regions of upward and downward motion. Upward motion is typically associated with clouds and precipitation.

Below is an ETA Model forecast panel for 300 mb winds and geopotential heights (white contours). The color filled regions indicate wind speed in knots and is color coded according to the legend at the bottom of the image. The shades of blue indicate winds less than 60 knots, while winds greater than 100 knots are given in shades of red.

The wind vectors (red arrows) are much smaller in the blue regions, where the winds are relatively weak, and largest in the red, which is the region of strongest winds. The ribbon of strongest winds (green, yellow and red colors) is called the jet stream with a jet maximum, or jet



Notice how the wind vectors are aligned generally parallel to the geopotential height contours. Once high enough above the earth, the effects of surface friction on wind direction decrease dramatically and